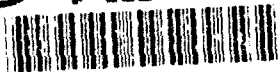


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7. 2. INFORMATION TO OTHERS: How and whether, including the time and frequency of release, including pending and future, and any releasing the collection of information. Some comments regarding this section are contained in the other part of the report. (b) INFORMATION REGARDING SERVICES: Comments for information regarding services and other comments are contained in the report to the Office of Management and Budget. Response Requested: (b)(7)(D) 100. Washington, DC 20540.

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3. REPORT TYPE AND DATES COVERED

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4. TITLE AND SUBTITLE

LOCATION AND CHARACTERIZATION OF IN-CLOUD LIGHTNING CURRENTS
BY MULTIPLE STATION VHF AND ELECTRIC FIELDS MEASUREMENTS

5. FUNDING NUMBERS

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

12. ABSTRACT (Maximum 200 words)

The network established in 1991 to measure electric fields in a 600 Hz to 3.5 MHz 3dB bandwidth at five stations at Kennedy Space Center was enhanced in 1992. New microprocessor-controlled remote controls were developed, additional remote calibration signals were added, and new sensor amplifiers were implemented so that we could record the derivative of the electric field, dE/dt . These improvements enabled us to increase our bandwidth from 3.5 MHz to 7 MHz and to record sharper signals (dE/dt) that allow better location accuracy. During the week of August 17-25 several days worth of storms formed over our network and provided excellent data on close lightning. Meteorological data were also obtained for these storms.

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14. SUBJECT TERMS

16. PRICE CODE

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08 DEC 1992

Annual Technical Report

Date 12/14/92

Title Location and Characterization of In-Cloud Lightning Currents by Multiple Station VHF and Electric Field Measurements

PI Ewen M. Thomson, University of Florida

Grant Number AFOSR-91-0093

Summary

The network established in 1991 to measure electric fields in a 600 Hz to 3.5 MHz 3dB bandwidth at five stations at Kennedy Space Center was enhanced in 1992. New microprocessor-controlled remote controls were developed, additional remote calibration signals were added, and new sensor amplifiers were implemented so that we could record the derivative of the electric field, dE/dt . These improvements enabled us to increase our bandwidth from 3.5 MHz to 7 MHz and to record sharper signals (dE/dt) that allow better location accuracy. During the week of August 17-25 several days worth of storms formed over our network and provided excellent data on close lightning. Meteorological data were also obtained for these storms.

Research Objectives

The overall purpose is to understand better the physics of in-cloud lightning processes that give rise to radiation pulses in the electric field record and to investigate the potential use of this radiation to provide early warning of thunderstorm activity.

The main scientific objectives are:-

(a) To establish the location and characteristics of initial discharge processes in both cloud and ground flashes;

(b) to identify, locate, and characterize any wideband events not associated with lightning but radiated from electrified clouds;

(c) to test the hypothesis of Weidman and Krider that the small pulses riding on the leading edge of large bipolar pulses are associated with channel formation;

(d) to test the commonly accepted hypothesis that K changes result from in-cloud streamers that propagate along pre-existing channels;

(e) to investigate the relationship between in-cloud current properties and thunderstorm activity as reflected in the flashing rate;

(f) to trace the location, channel orientation and current polarity of rapid discharge processes in intracloud flashes to determine whether the preferred mechanism involves negative or positive charge;

(g) to locate and characterize the narrow pulses previously detected, but not located, by Le Vine and Willett.

Status of the Research

In 1992 we significantly enhanced our existing system capabilities by developing completely new microprocessor-controlled remote controls, adding several new remote calibration signals, and implementing new sensor amplifiers so that we could record the derivative of the electric field, dE/dt . These improvements enabled us to increase our bandwidth from 3.5 MHz to 7 MHz and to record sharper signals (dE/dt) that allow better location accuracy. Data were recorded 24 hours per day. In particular, during the week of August 17-25 several days worth of storms formed over our network and provided excellent data on close lightning. Meteorological data were also obtained for these storms. We utilized a video camera on top of the ROCC at Kennedy Space Center to record cloud growth and visible lightning channels and recorded 10 kft CAPPI's from the McGill radar at 10-20 minute intervals throughout the storms. These indicated that the region of storm activity generally advected over the KSC area from a westerly direction, with new cells forming on the easterly flank of the activity. Analysis is presently under way to investigate the first lightnings in these new cells.

The close lightning recorded at five stations enabled us to check our timing calibrations by observing whether return stroke fields originated near ground level. With the help of new analysis software that displays the multiple signals so that locations can be obtained for any feature of the waveshape, and using the new calibration signals, we found that the corrections needed to ensure this location consistently were up to 400ns, much larger than the 50ns error we were expecting. We attribute this error to variations in the speed of propagation for the TV signals that we used for our calibration source. Accordingly, we are developing several different techniques for the timing calibration:- (i) use of the inherent redundancy in our system, especially for ground flashes; (ii) direct measurement of the propagation delays in our signal links; and (iv) use of a different TV station in Melbourne. Until the calibrations have been reliably established using at least two different techniques, we cannot confidently find the locations of the source currents.

Articles Planned for Publication

No articles have been published concerning the research. However, several are planned:-

(i) Title: E and dE/dt waveshapes for narrow pulses radiated from thunderstorms

Authors: Medelius, Thomson

Journal: Journal of Geophysics Research

(ii) Title: The effect of a propagating source region on the narrowband VHF radiation received at spatially separated stations

Authors: Thomson, Medelius

Journal: Journal of Geophysics Research

(iii) Title: The amplitude spectra of narrow pulse width radiation electric fields from thunderstorms in a 180 MHz bandwidth

Authors: Medelius, Thomson

Journal: Journal of Geophysics Research

(iv) Title: Narrow bipolar electric field pulse locations in an immature thunderstorm

Authors: Medelius, Thomson

Journal: Geophysics Research Letters

Participating Professionals

Ewen Thomson, Associate Professor
Pedro Medelius, Senior Engineer, Boeing Aerospace
Jamie Stone, Scientific Programmer

Conference Presentations

American Geophysical Union Fall Meeting, San Francisco, December 1992

Title: The Effect of a Propagating Source Region on the Waveshapes of Narrow Band VHF Radiation
Presenter: Thomson

Other Interactions

Subject matter: Operational Benefits of the TOA System at Kennedy Space Center
Location: Kennedy Space Center
Date: February 16, 1992
Names and affiliation: Jim Nicholson, Jan Zysko, Frank Merceret, Bill Jones, William Jafferis, and Boeing ESC personnel, Kennedy Space Center

New Discoveries and Applications

The multiple station network (TOA system) is still permanently installed at Kennedy Space Center under the on-site control of Pedro Medelius and is available for operational use by KSC. Its control system is now significantly faster and easier to use and location accuracies are improved by about a factor of five.

A major discovery is that velocities of source propagation derived from TOA systems using narrowband VHF receivers have errors that can be as large

as the speed of light. This finding casts doubt on all the velocities found by Proctor for the VHF sources that cause "P" and "Q" noise and further validates our system design using only baseband.

A discovery that our timing calibration technique introduced larger-than-expected errors has led us to the conclusion that variations in the speed of propagation of electromagnetic waves over conducting ground is an effect that cannot be ignored, at least at the 600MHz frequency of the TV broadcast that we used for our calibration. This represents another source of error in systems such as Proctor's but is less serious at the lower frequencies (up to 7MHz) that we detect.